11 NOISE AND VIBRATION

11.1 INTRODUCTION

This chapter of the Environmental Impact Assessment Report (EIAR) describes the potential noise and vibration impact from the proposed Shronowen wind farm project. A detailed description of the project, including the wind farm is provided in **Chapter 2** of this EIAR.

Noise and vibration assessments were undertaken for the construction, operational and decommissioning phases of the proposed development to the nearest noise sensitive locations. It is worth noting that construction noise from the wind farm itself is the worst-case scenario for the construction of the project as the works along the turbine delivery route are of a much less scale and duration. Accordingly, the noise sensitive receptors relate to the construction and operation of the wind turbines.

11.1.1 Competency of the Assessor

This chapter has been prepared by Peter Barry of Malachy Walsh and Partners. Peter (Senior Acoustic and Environmental Consultant) holds a BSc in Agricultural and Environmental Science and an MSc in Energy Management. Peter has worked in the field of acoustics for 19 years. Peter has extensive experience in the measurement, prediction, assessment and control of environmental noise. Peter is a member of the Institute of Acoustics (IOA) and successfully completed the IOA diploma in Acoustics and Noise Control. Peter has carried out numerous wind farm noise assessments and has presented evidence as expert witness on noise at oral hearing and in court.

11.1.2 Noise Emissions from a Wind Farm Development

The main sources of noise from a wind turbine include aerodynamic noise (rotating blades in the air) and mechanical noise (gearbox (if not a direct drive system) and generator).

Noise only occurs above the 'cut-in' wind speed and below the 'cut-out' wind speed. The typical 'cut in' wind speed of a modern turbine is 3 meters per second (m/s) and the 'cut-out' wind speed is approximately 25 to 30 m/s.

The Vestas V136 has been modelled in the proceeding analyses as the preferred turbine candidate for the site. This turbine is a pitch regulated upwind turbine. Ultimately, the most appropriate turbine model and operating modes will be selected in order to achieve the noise limits criteria. The chosen turbine will comply with the parameters assessed.

Construction noise will occur during excavation and earth moving, laying of roads and hard standings, transportation of materials and erection of the wind turbines. The construction phase will be phased and temporary. The decommissioning phase works will be similar in magnitude to the construction phase.

11.1.3 Note on the 2019 Draft Wind Energy Development Guidelines

It is acknowledged that the 2006 Wind Energy Development Guidelines are currently being revised. A draft version of the replacement Wind Energy Development Guidelines (WEDG) was published in December 2019. There is no timeline on the publication of the finalised document and ,at the time of writing, the 2006 Guidelines were in force until the new WEDGs are published in final form. As the 2019 Draft WEDGs have undergone further consultation and have yet to be finalised, they are subject to further change, as happened between the 2017 information note and 2019 draft.

The noise limits set out in the 2006 guidelines are currently the guidelines which An Bord Pleanala must have regard to and which are adopted by the expert community when assessing the potential impact from wind farm noise. However, regard has been had to the more detailed methodology set out in the 'Good Practice Guide [GPG] to the application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise' (Institute of Acoustics, 2013) with respect to the baseline survey methodology.

It is not possible to assess against the draft document as the parameters for assessment are not known at this stage.

11.1.4 Fundamentals of Noise

Fundamentally, noise is vibrations of the air which are detectable by the ear. Sound waves radiate out spherically from a sound source in three dimensions.

The human ear can detect a very wide range of pressure variations. In order to cope with this wide range, a logarithmic scale (decibel (dB) scale) is used to translate pressure values into manageable numbers from 0dB to 140 dB. 0 dB is the threshold of hearing and 120 dB is the threshold of pain.

Measuring in decibels means that a 3 dB increase is equivalent to a doubling of the sound energy and a 10 dB increase is a tenfold increase in energy. For broadband sounds which are very similar in all but magnitude, a change or difference in noise level of 1 dB is just perceptible under laboratory conditions, 3 dB is perceptible under most normal conditions and a 10 dB increase generally appears twice as loud.

A healthy human ear is also sensitive to a large range of frequencies (approximately 20 Hz to 20,000 Hz) and varies in sensitivity depending on the frequency.

The human ear is not equally sensitive to sound at all frequencies and is less sensitive to sound at low frequencies and high frequencies. A -weighting (dB A) is the main way of adjusting measured sound pressure levels (noise) to take account of the uneven human response to frequencies.

Figure 11-1 illustrates some everyday sounds on the dB(A) scale. A quiet bedroom is around 35 dB(A), a busy office around 60dB(A) and a rock concert around 100 dB(A). The illustration is extracted from draft Wind Energy Development Guidelines 2019.

Figure 11-1 The Level of Typical Common Sounds on the dB(A) Scale

11.1.5 Scope of Assessment

The scope of the assessment has been defined by industry standard best practice and guidance **(refer to Section 11.2**) used in Ireland. In general, this includes:

- Establishing the existing or baseline noise conditions at representative noise sensitive receptors in this case, residential dwellings.
- Establishing noise limits based on the measured baseline noise levels in accordance with best practice and guidance.
- Using computer software, predict the noise emissions from the proposed wind farm and associated infrastructure at the nearest noise sensitive receptors.
- Comparing the wind farm noise emissions against the noise limit criteria. The predicted wind farm noise emissions must not exceed the noise limit criteria.

Once operational there will be noise from the wind turbines and the associated substation. There will be noise from plant and machinery during the construction phase of the project. No significant noise effects are expected from the replacement forestry lands and it is anticipated that planting will be carried out manually. The noise associated with felling is typical of forestry operations and will be carried out in accordance with Forest Service Guidance and the felling licence approval. The replacement forestry lands are therefore scoped out from further assessment in this chapter. Similarly, the works areas along the turbine delivery route will be contained to each of the minor site areas and will be of short duration and temporary. There will not be significant impacts from this part of the project development and they have been scoped out from further assessment.

11.2 METHODOLOGY

In general, the methodology used to assess the noise impact from wind farms includes extended measurements of the existing background noise levels (across a range of wind speeds) at nearby representative dwellings and comparisons against the predicted noise output from the wind farm, which also varies with wind speed. The methodology and planning guidance framework are described in the following sections.

11.2.1 Operational Wind Farm Noise Policy and Guidance

As with any development a balance must be struck between the noise restrictions placed on a wind farm, the protection of amenity and the national and global benefits of renewable energy development. The guidance documents used in the preparation of this chapter represent best practice in assessing wind farm noise and are outlined as follows:

Department of the Environment, Heritage, and Local Government (DoEHLG) – Wind Energy Development Guidelines (2006)

This document provides the framework for wind farm noise assessment in Ireland. The noise limit thresholds in this publication are those currently endorsed by the Irish Government and deemed to strike the balance between the protection of residential amenity and renewable energy developments. These guidelines remain in force until the final version of the replacement WEDGs is published.

A Good Practice Guide (GPG) to the application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (Institute of Acoustics (IOA), 2013)

This publication was issued by the Institute of Acoustics in May 2013. This assessment adopts the recommendations of the GPG regarding the baseline survey methodology and the establishment of the prevailing background noise levels. The 2006 DoEHLG document is lacking in detail in this regard and the IOA GPG is considered the best scientific approach in the absence of more detailed guidance on these areas in the current Irish guidelines.

11.2.2 Construction and Decommissioning Phases Impact Assessment- Best Practice and Guidance

There are no mandatory noise limits for construction noise in Ireland. The most recent revision of *British Standard 5228-1:2009+A1:2014, Code of practice for noise and vibration control on construction and open sites.* outlines noise thresholds for significant impacts.

The Irish National Roads Authority (NRA) - *Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes*, March 2014 was also consulted for noise and vibration related impact nuisance thresholds.

The construction and decommissioning works will be broadly similar. Similar plant and machinery will be involved, the assessment criteria will be the same and both will be temporary impacts of short duration. Therefore, for the purpose of this assessment the conclusions of the construction phase impacts can be assumed for the decommissioning phase.

11.2.3 Assessment Criteria

11.2.3.1 Criteria for Evaluating the Operational Phase Impact from Wind Turbines

Current wind farm noise limit thresholds are described in the Department of Environment Heritage and Local Government (DoEHLG), *Wind Energy Development Guidelines*, 2006.

It recommends that noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed. Wind turbine noise is directly related to wind speed. Therefore, the guidelines are based on the principle that turbine noise should be controlled with reference to fixed limits when background noise is low, or relative to background noise itself as it increases with wind speed, whichever is the greater. The interpretation of these limits is that turbine-attributable noise should be limited to:

- 43 dB $L_{A90\ 10min}$ for night-time hours or 5 dB above background noise, whichever is the greater, at the noise sensitive receptor for night-time hours
- 45 dB $L_{A90\ 10\ min}$ or 5 dB above background noise, whichever is the greater, at the noise sensitive receptor for daytime hours
- 35 to 40 dB $L_{A90\ 10\ min}$ or 5 dB above background noise, whichever is the greater, at the noise sensitive receptor where background noise is less than 30 dB L_{A90}.

For the purpose of this assessment the fixed lower limit has been set at L_{90} 40dB(A). This lower limit value for areas of low background noise is lower than typical noise limits (L_{A90} 43dB or 5 dB above background) set down in recent planning conditions for similar developments in the area.

11.2.3.2 Criteria for Evaluating Construction and Decommissioning Noise Effects

There is no statutory guidance in Ireland relating to the maximum noise levels permitted during construction works and, in the absence of statutory guidance or other specific limits prescribed by local authorities, the thresholds outlined in the *British Standard 5228-12009+A1:2009, Code of Practice for Noise and Vibration Control on Construction and Open Sites - Noise* has been adopted in this assessment, as they are recognised by the expert community as the most appropriate in the assessment of construction noise. The noise levels, which are reproduced in **Table 11-1**, are typically deemed acceptable.

Table 11-1: Construction Stage Noise Level Thresholds

Assessment category and threshold value period (T)	Threshold values, L_{AeqT} dB		
	Category A Note A	Category B Note B	Category C Note
Night-time (23:00 to 07:00hrs)	45	50	55
Evening and Weekends Note D	55	60	65
Daytime (07:00 – 19:00hrs) and Saturdays (07:00 -13:00hrs)	65	70	75

Note A: Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values.

Note B: Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values.

Note C: Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.

Note D: 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays.

Given the rural nature of the site, all properties will be afforded a Category A designation. Therefore, if the predicted daytime construction noise exceeds 65dB $L_{Aeq(T)}$ then this is assessed as a significant impact.

11.2.3.3 Criteria for Evaluating Construction and Operational Vibration Effects

Vibration emissions are limited to the construction phase of the proposed development. Once operational, there will be no significant vibrations from any element of the development.

According to *NRA's 2014 Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes,* there are two separate considerations for vibration during the construction phase namely 1) that which affects human comfort and 2) that which affects cosmetic or structural damage to buildings.

The guidelines suggest that human tolerance for daytime blasting and piling, two of the primary sources of construction vibration, limits vibration levels to a peak particle velocity (ppv) of 12mm/s and 2.5mm/s respectively. If poor ground conditions are encountered during excavation and a significant depth to sub-formation is required, a piled foundation may be considered. A piled foundation requires the use of a piling machine equipped with an auger drill to rotary bore several holes around the area of the turbine base to the sub-formation depth determined at construction stage. Given the separation between the turbine locations and nearest dwellings there will be no significant impact.

To avoid the risk of cosmetic damage to buildings, the guidelines suggest that vibration levels should be limited to 8mm/s at frequencies of less than 10Hz, to 12.5mm/s for frequencies of 10 to 50Hz, and to 20mm/s at frequencies of 50Hz and above.

11.2.3.4 Cumulative Impact

The potential for cumulative impact has been assessed. The projects where the potential for cumulative impact could occur are identified below.

11.2.3.4.1 Other Wind Farms in the Area (Operational)

The wind farms included in the cumulative assessment include (**refer to Figure 11-3**):

Tulahennell Wind Farm – Operational.

Ballylongford Wind Farm (an extension of Tullahennell) – Permitted but not constructed. The Permission states in Condition 9 of ABP reference: ABP-304807-19.

The operation of the proposed development, by itself or in combination with any other permitted wind energy development, shall not result in noise levels, when measured externally at nearby noise sensitive locations, which exceed:

> *(a) between the hours of 0700 and 2300:*
> *the greater of 5 dB(A) $L_{90,10min}$ above background noise levels, or 43 dB(A) $L_{90,10min}$, and*
>
> *(b) 43 dB(A) $L_{90,10min}$ at all other times where wind speeds are measured at 10 metres above ground level.*

Leanamore Wind Farm – Operational. The Permission states in Condition 8 of ABP reference: ABP-08.239233

Wind Turbine Noise (measured as L_{Aeq}) at dwellings or other sensitive receptors shall not exceed 43 dB(A) L_{A90} externally.

The 43dB(A) L_{90} lower limit value is common to all permissions granted and is the main assessment criteria herein both stand alone and cumulatively.

For the assessment presented in this report the Leanamore and Tulahennell (as built) wind farms and Ballylongford (permitted) wind farm have been included in the cumulative noise model and the total wind turbine noise level of all wind farms is predicted for all the houses shown on **Figures 11-2 and 11-3**. The predictions assume that all wind turbines (for all schemes) are operating in standard noise mode. The impacts of wind direction are not included in the prediction calculations. Noise levels at a sufficient distance upwind of wind turbines will be lower. It has been assumed that all receptors are downwind of all turbines simultaneously.

11.2.3.4.2 Other Wind Farms in the Area (Construction)

The permitted Ballylongford wind farm is not yet constructed. The construction programme is not known. However, the construction works areas are over 3 kms from the Shronowen works areas. At such separation distances there will be no significant cumulative noise impacts.

11.2.3.4.3 Tullamore Solar PV Farm

Planning permission has been granted for a solar PV farm at Tullamore, Drombeg and Coolkeragh, Listowel Co Kerry (ABP ref ABP-302681-18). It is approximately 1.5 km south of the proposed Shronowen wind farm. The solar panels do not produce any noise and little operational maintenance is required on an ongoing basis. There will therefore be no operational cumulative impact from this permitted development.

A 100kv substation will form part of the solar development infrastructure but is subject to a separate planning application. The substation is currently the subject of a section 182E preapplication consultation request to An Bord Pleanala. It is reasonable to assume that this development will secure planning permission. It is understood that the proposed substation location is at least 400 m to the nearest dwelling. At such separation distances the proposed substation is unlikely to be perceptible, therefore there can be no cumulative impact with the wind farm.

The sound power levels for a typical substation of this size is in the order of 93dB(A). No details on the substation were provided in the solar PV planning application. At 400 m this equates to approximately 33dB(A) at the nearest receptor (attenuation due to distance only). This is 10dB(A) below the cumulative limit criteria. Due to logarithmic of decibels if one noise source is 10 dB(A) below another, then there is no cumulative impact.

The timeline for construction is not known at this stage. It makes sense that the substation and solar panels will be constructed simultaneously. It was proposed for 2019. In general, the construction of a solar farm is relatively minor and low impact. The construction programme is relatively short i.e. approximately 20 weeks for the solar panels and 7.5 weeks for the substation. Any construction cumulative impacts can be avoided through timing.

11.3 EXISTING RECEIVING ENVIRONMENT

This section describes the existing environment in terms of the noise monitoring locations, existing noise sources at these locations and the prevailing background noise levels.

The wind farm is to be developed in a rural area of county Kerry. A detailed description of the locality is provided in **Chapter 2** of this EIAR. The land use in the immediate area is mainly agricultural. This also applies to the works areas of the turbine delivery route.

The main sources of noise in the area includes traffic on the local and regional road network, and machinery involved in working agricultural land. Natural noise sources include wind borne noise in vegetation and water in streams.

The noise sensitive receptors (NSR's) are dwellings in typical ribbon style development along the local road network.

The following sections describe how the existing pre-development noise environment was measured and characterised.

11.3.1 Noise Sensitive Receptors

At the start of the noise assessment, a preliminary desktop modelling exercise was undertaken using computer software in order to locate noise sensitive receptors (NSR's) which may be affected and to identify suitable locations at which to monitor background noise. The first iteration of the wind turbine layout was input into the software using noise data for the candidate turbine representative of the type that could be installed on the site.

The noise contour plot predicted wind turbine noise levels at the NSR's surrounding the proposed development with predicted turbine noise (measured in dB(A), L_{90}) decreasing with distance from the proposed development. All properties or clusters of properties within or close to the 35dB(A) contour were then identified and assessed to determine which NSR's would provide representative background noise data for others in the area. Irrespective of the 35dB(A) contour noise level, predictions for all receptors numbered in **Figure 11-2** were calculated.

In accordance with the Institute of Acoustics' Good Practice Guide (IOA GPG), the noise contour plot is based on a noise level at a wind speed of 8 m/s (as standardised to 10m height) as the manufacturer determined that this is the wind speed with the highest predicted noise level for the candidate turbine, namely the Vestas V136 turbine.

The EPA's Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (2016), defines a noise sensitive location as "*any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or other area of high amenity which for its proper enjoyment requires the absence of noise at nuisance levels*".

In total, six (6) noise monitoring locations (NML) were selected to characterise the existing noise environment and derive the noise limit criteria for potentially impacted locations (refer to **Figure 11-2**). These locations were carefully selected in accordance with guidelines, to characterise the existing local noise environment. A description of the noise monitoring locations is presented in **Table 11-2**.

Table 11-2 Noise Monitoring Locations

NML Number	Receptor Reference	Representative of	Approximate GPS
NML 1	15	15/124/126	500718.2 642118.7
NML 2	363	343 / 344 / 363 / 364	499246.6 641745.2
NML 3	1	1/ 398	498613.3 640726.7
NML 4	271	254 /255 / 270 / 271	499031.1 639630.4
NML 5	241	214 / 242 / 243 / 244 / 263 / 264	500472.4 639263.6
NML 6	129	285 / 129 / 379 / 305	501659.9 640356.4

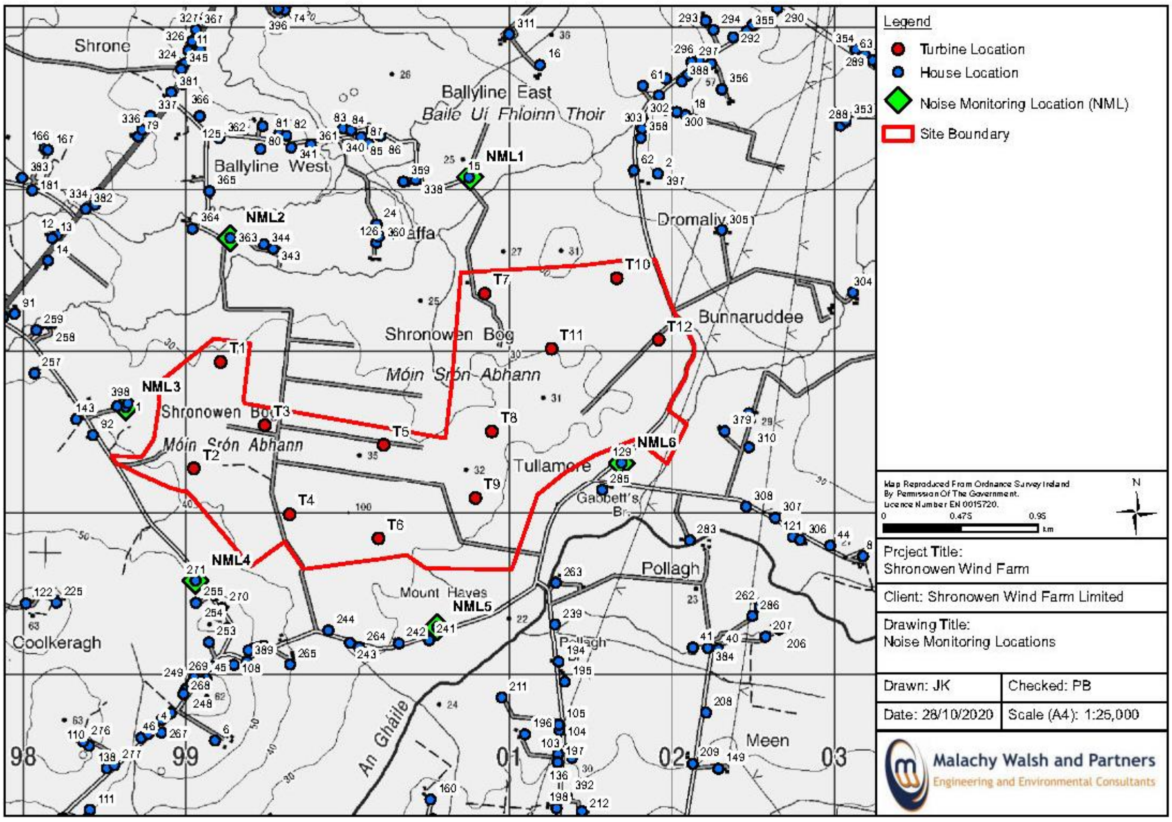


Figure 11-2 Noise Monitoring Locations and Noise Sensitive Receptors

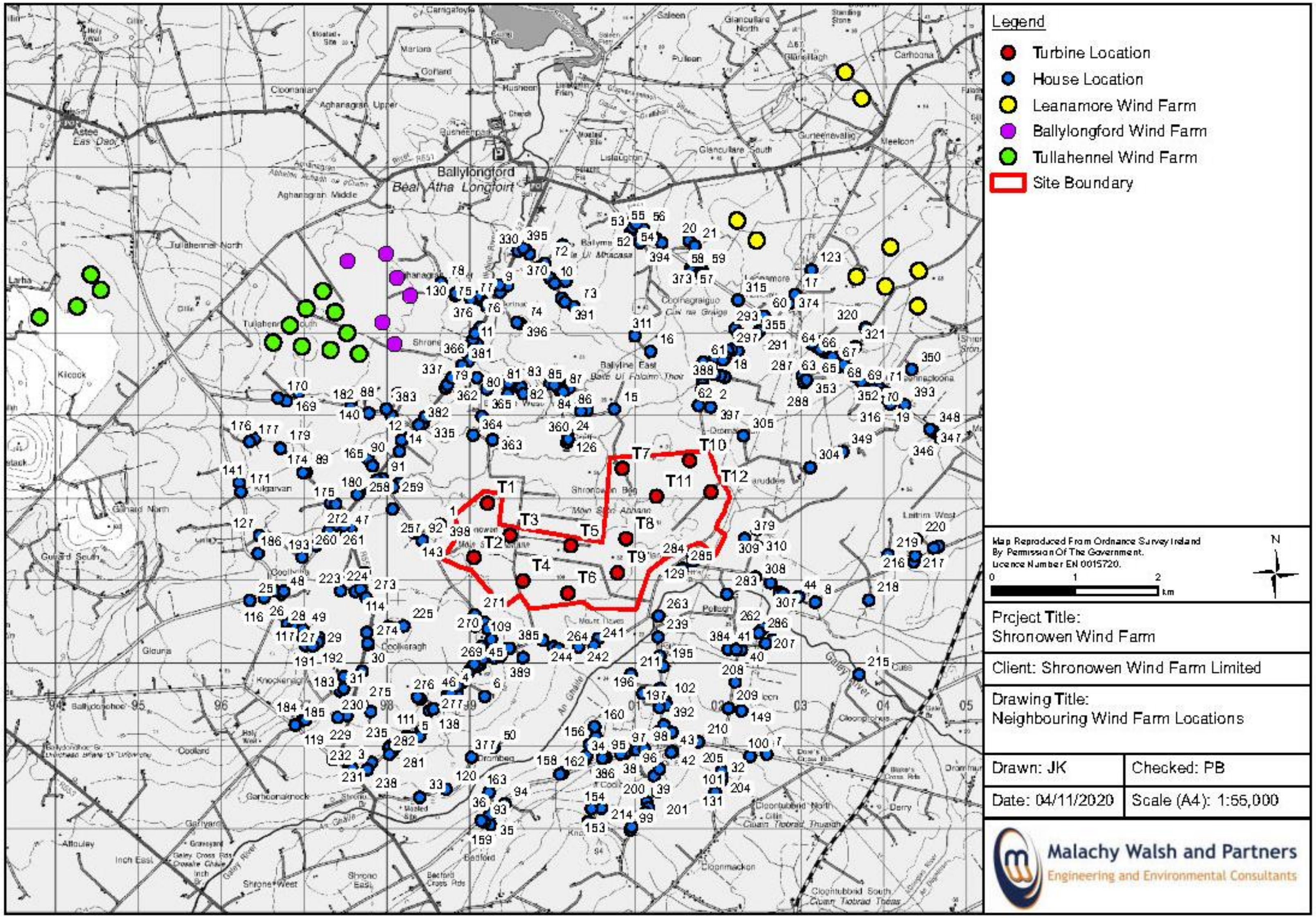


Figure 11-3 Other wind farms in the area

11.3.2 Background Noise Monitoring

Background noise monitoring was undertaken over the period 25th April to 16th May 2019. Details of the exact monitoring periods, the rationale behind the exact kit location and the dominant noise sources observed at each of the Noise Monitoring Locations (NML) were detailed in Field Data Sheets (FDS) (refer to **Appendix 11-1**). The noise survey equipment was installed in accordance with the Institute of Acoustics' 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise' (IOA GPG).

11.3.2.1 Noise Monitoring Equipment

Section 2.4 of the IOA GPG May 2013, includes information on the type and specification of noise monitoring equipment which should be used for background noise surveys and states:

Noise measurement equipment and calibrators used on site should comply with Class 1/ Type 1 of the relevant standard(s). Enhanced microphone windscreens should be used. Standard windshields of a diameter of less than 100 mm cannot be relied upon to provide reduction of wind noise in most circumstances.

The noise monitoring equipment used for the background noise survey meets with the requirements of the IOA GPG. Details of the noise monitoring equipment, the calibration drift recorded and photographs at each NML are detailed in the FDS. The IOA GPG states that, for calibration drift greater than 0.5dB but less than 1 dB, results may still be valid but should be corrected by the amount of the calibration drift where such corrections would result in lower noise levels. The maximum calibration drift did not exceed 0.5dB as detailed in the FDS therefore no correction has been applied to the noise data.

Copies of the calibration certificates for the sound level meters and sound level calibrator used for the noise survey are attached as **Appendix 11-2.**

The microphones were all mounted between 1.2 m and 1.5 m above ground level, situated between 3.5 and 20m from the dwelling, where possible. Where this was not possible for location specific reasons, an alternative but representative location was chosen nearby, in line with the IOA GPG. The rational for each location is described in the FDS. The noise meters were located away from obvious sources of noise such as boiler flues, fans and running water. The meters were situated away from hard reflective surfaces such as fences and walls.

11.3.2.2 Meteorological Data

Regards is had to the IOA GPG when correlating wind speeds and background noise. In general background noise measurements should be correlated with wind speed measurements performed at the proposed site, such that actual operating noise levels from the turbines may be compared with the noise levels that would otherwise be experienced at a dwelling.

The IOA GPG states that three methods of wind speed measurement may be adopted.

A) Direct Measurement at hub height using a large mast or Lidar/ Sodar unit;
B) A met mast lower than hub height but carrying anemometers at two different heights; these are then used to calculate hub height wind speed; and
C) A met mast carrying an anemometer at 10 metres height.

The IOA GPG states that methods A and B are preferred, and that Method C *should only be adopted for smaller-scale developments for which the installation of a tall met mast or deployment of a SODAR or LIDAR system at the planning stage might not be justified economically.*

For this assessment wind speeds were recorded using Method B.

11.3.2.3 Wind Shear

Wind shear can be defined as the changes in the relationship between wind speed at different heights. Due to wind shear, wind speeds recorded on one meteorological mast, at different heights, are usually different. Generally, the higher the anemometer the higher the wind speed recorded. For example, if a wind speed of 4 m/s is recorded at 80m height, 3.5 m/s may be recorded at 40 m and 2.5 m/s may be recorded at 10 m.

The issue of wind shear has been considered in accordance with the IOA GPG. Wind speed measurements at two different heights from the on-site met mast were standardised to 10 m using the following equations.

Equation A

Shear Exponent Profile - this uses the following equation:

$$\mathbf{U = U_{ref} \times (H \div H_{ref})^{m}}$$

Where:

U	=	calculated wind speed
Uref	=	measured wind speed
H	=	height at which the wind speed will be calculated
Href	=	height at which the wind speed is measured
m	=	shear exponent

Equation B

Roughness Length Shear Profile – this uses the following equation:

$$\mathbf{U1 = U2 \times [(\ln (H_1 \div z))/ (\ln (H_2 \div z))]}$$

Where:

H_1	=	The height of the wind speed to be calculated (10m)
H_2	=	The height of the measured wind speed
U_1	=	The wind speed to be calculated
U_2	=	The measured wind speed
z	=	The roughness length

Note: A roughness length of 0.05m is used to standardise hub height wind speeds to 10m height in the IEC 61400-11:2003 standard, regardless of what the actual roughness length seen on a site may have been. This 'normalisation' procedure was adopted for comparability between test results for different turbines.

A data set from the met mast was available for the duration of the baseline noise survey undertaken here. This data set was used to perform a calculation of the shear exponent found between the highest two wind speed measurements for every ten-minute period using the equation:

$$\mathbf{M = \ln (v_2 \div v_1) / \ln (h_2 \div h_1)}$$

Where:

V_1 = wind speed at lower anemometer h_1
V_2 = wind speed at higher anemometer h_2

The shear exponents calculated for every ten-minute period were then used to calculate the hub height wind speed from that measured at the relevant hub height proposed here, using equation B. Equation A was then used to calculate a ten-metre height wind speed from the hub height wind speed every ten minutes, assuming the reference roughness length of 0.05 m.

11.3.2.4 Filtering and Analysis of Data

Analysis of the measured data has been undertaken in accordance with the recommendations of the IOA GPG.

The purpose of data analysis is to provide a representative background noise level across a range of wind speeds for Amenity and Night-time Hours and thereby help define appropriate noise limits for a proposed wind energy development.

To obtain a typical representation of the existing noise environment, analysis of the collected data should minimise the influence of atypical sources for a representative location (or other locations for which a proxy is being applied) during the period of noise measurement.

The guidance requires the filtering of noise, wind and rain data for Amenity and Night-time hours which are defined as follows:

Amenity hours
18:00 to 23:00 hrs. Monday to Sunday
13:00 to 18:00 Saturday and 07:00 to 18:00 Sunday.

Night-time
23:00 to 07:00 (weekday and weekend)

Raw meteorological data was screened upon receipt and, where rainfall occurred, the noise and wind speed data has been excluded from the assessment.

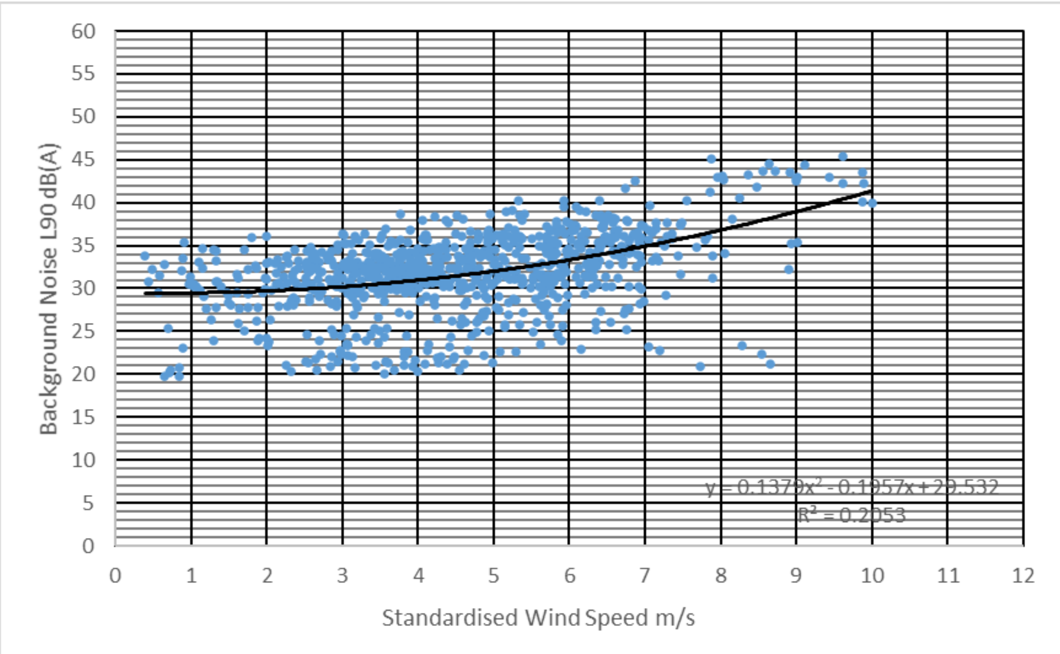
The potential impact of a dawn chorus was also removed by filtering night-time hours to 23:00 to 04:00.

Additionally, any data which looked erroneous and may have elevated background noise levels was removed from the data set.

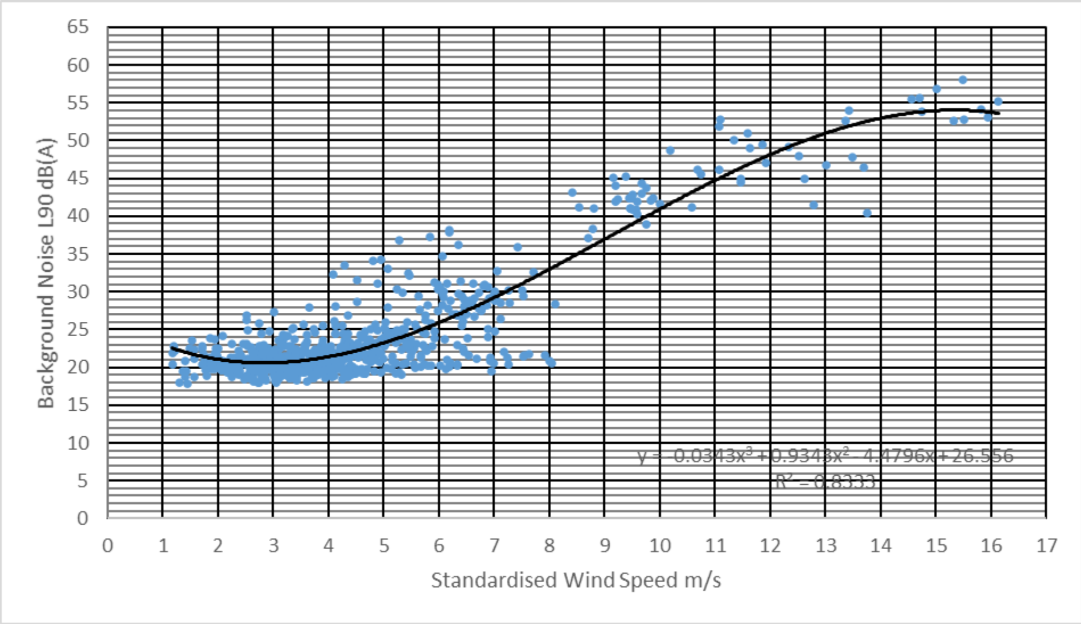
11.3.2.5 Prevailing Background Noise Levels

The prevailing measured background noise levels have been calculated using a best fit polynomial regression line of no more than a fourth order through the measured $L_{A90\ 10\ min}$ noise data, as required by the IOA GPG. The regression analysis curve is shown as a continuous black line on the following series of graphs. The graphs show the 10-minute average wind speeds plotted against the 10-minute average recorded noise levels at the noise monitoring locations along with a calculated best fit for the quiet daytime and night-time periods.

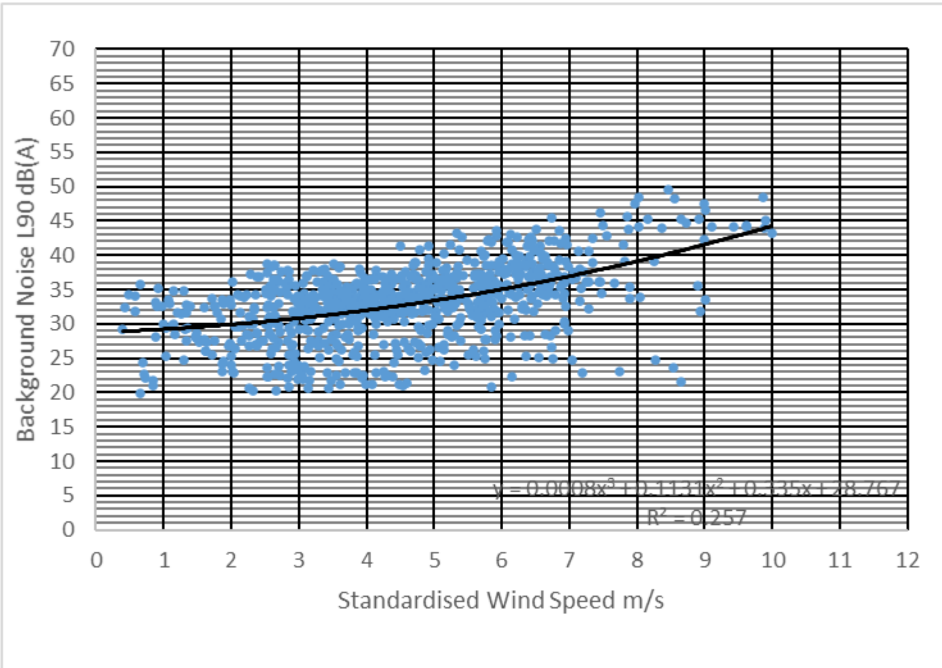
NML 1 Amenity Hours Prevailing Background Noise Level



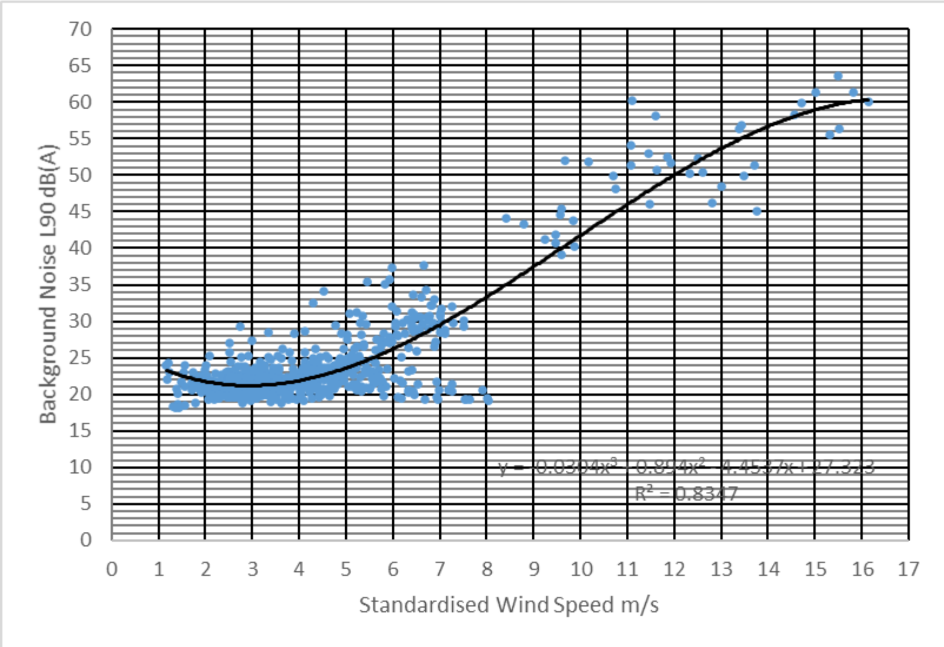
NML 1 Night-time Prevailing Background Noise Level



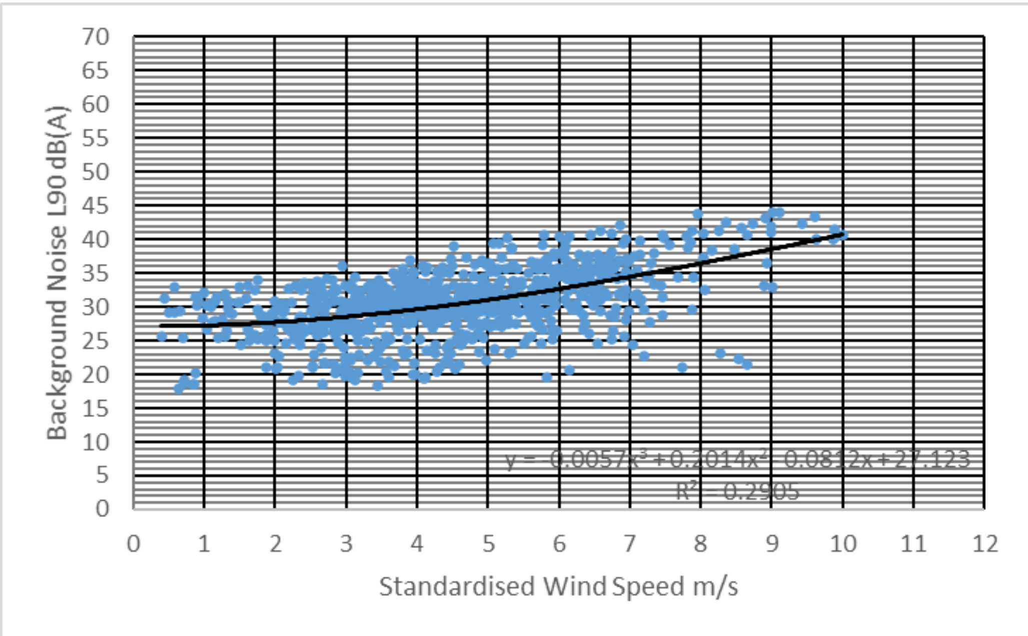
NML 2 Amenity Hours Prevailing Background Noise Level



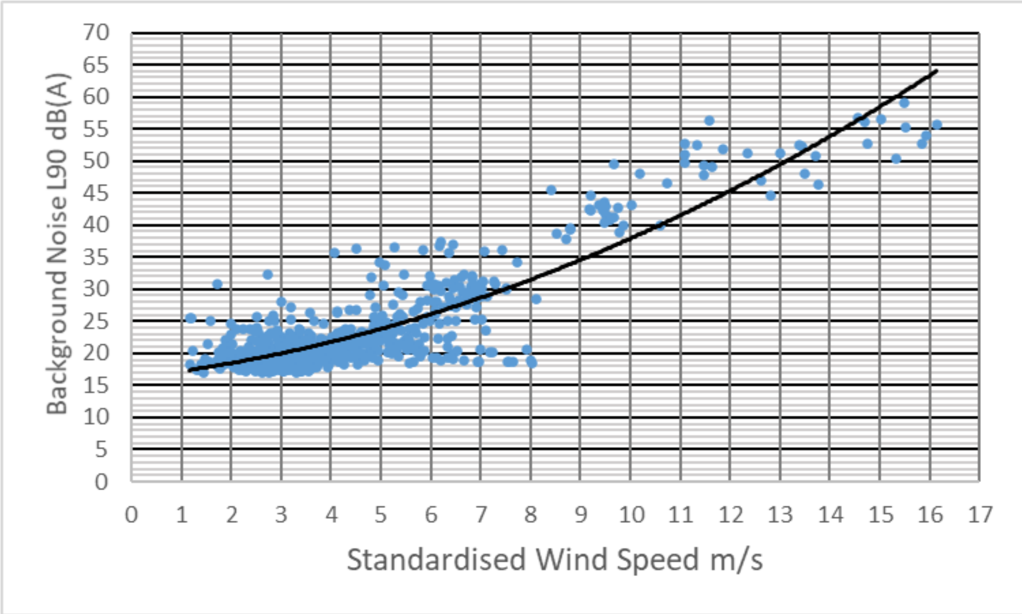
NML 2 Night-Time Prevailing Background Noise Level



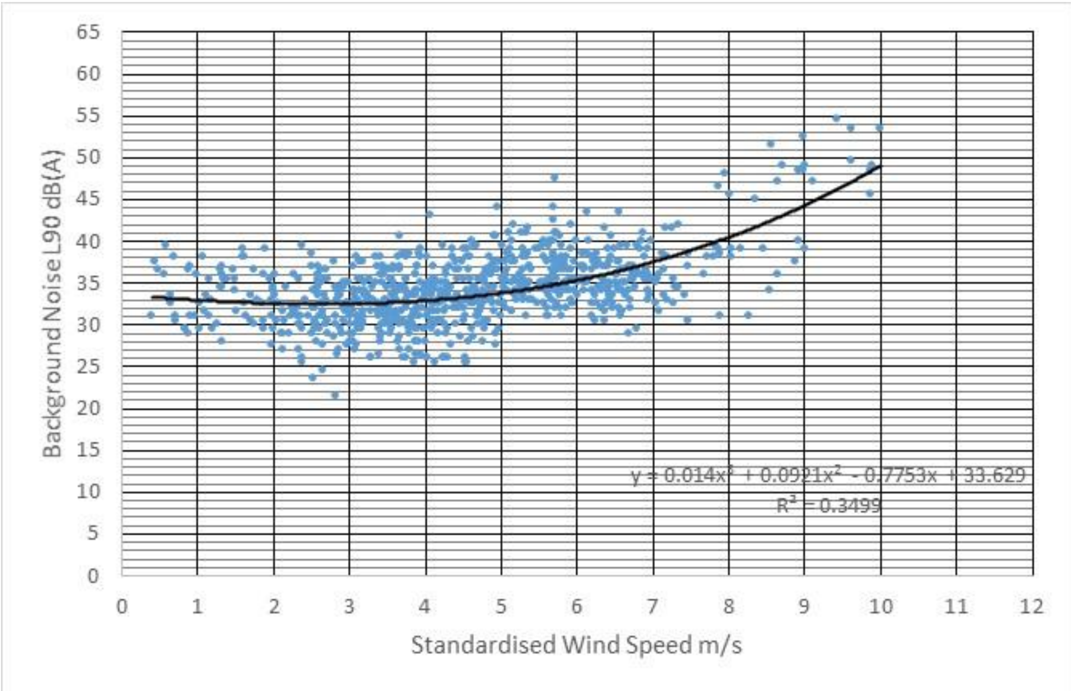
NML 3 Amenity Hours Prevailing Background Noise Level



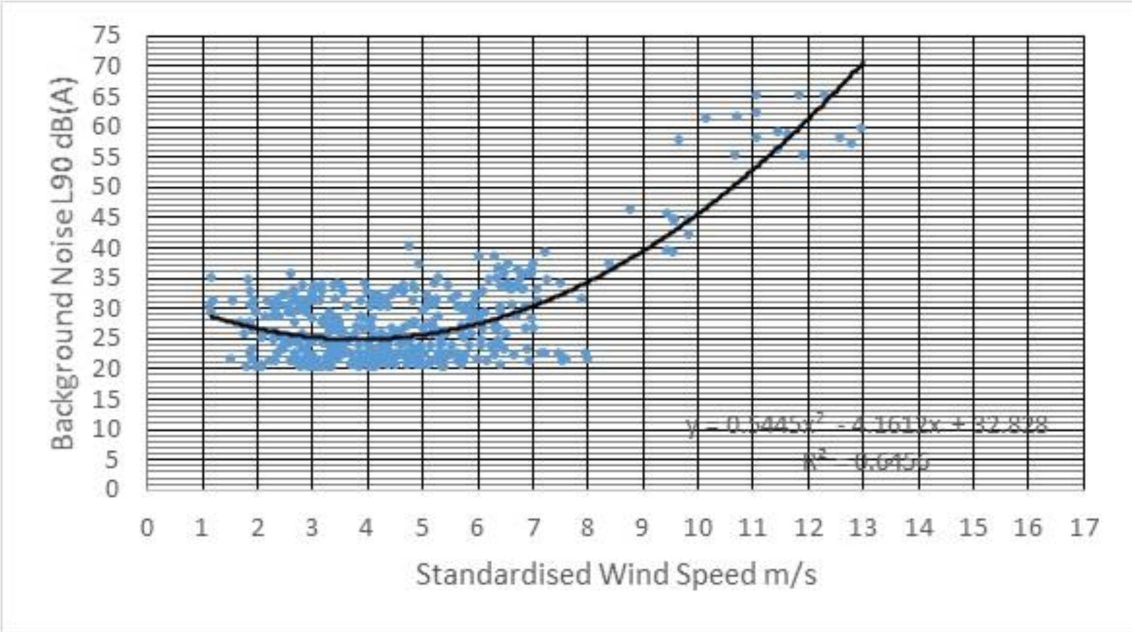
NML 3 Night-Time Prevailing Background Noise Level



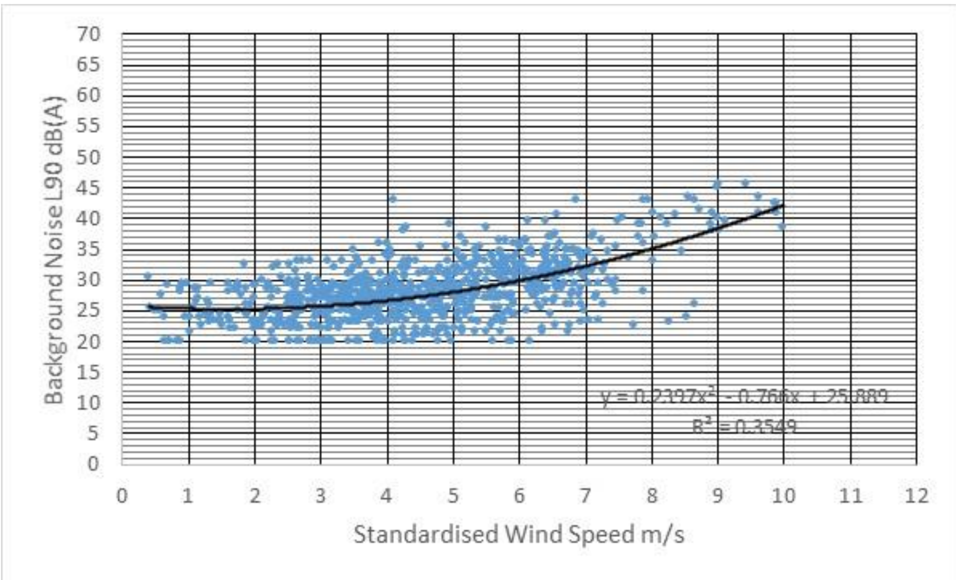
NML 4 Amenity Hours Prevailing Background Noise Level



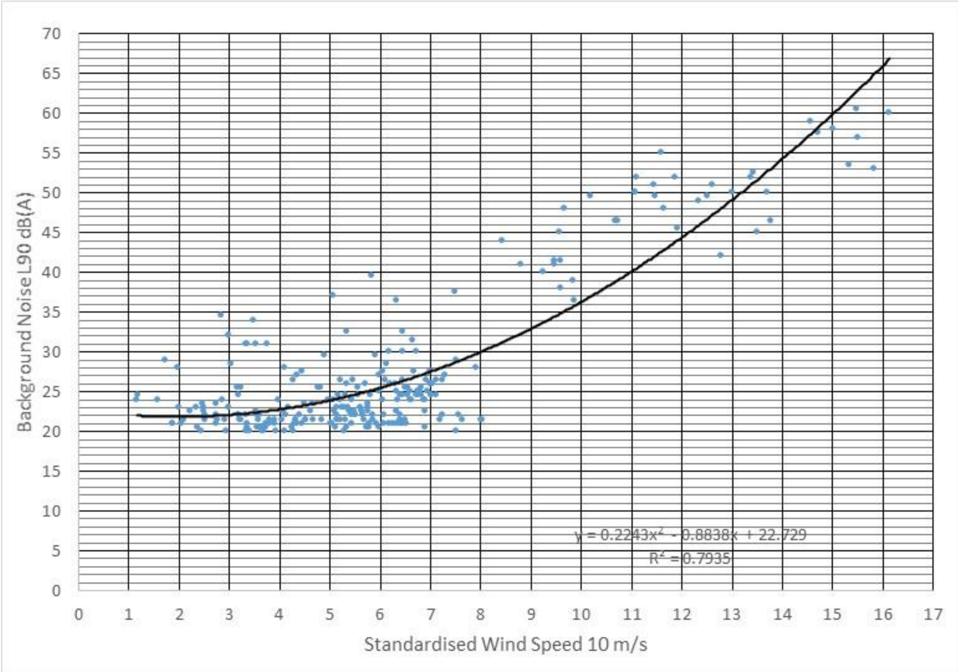
NML 4Night-Time Prevailing Background Noise Level



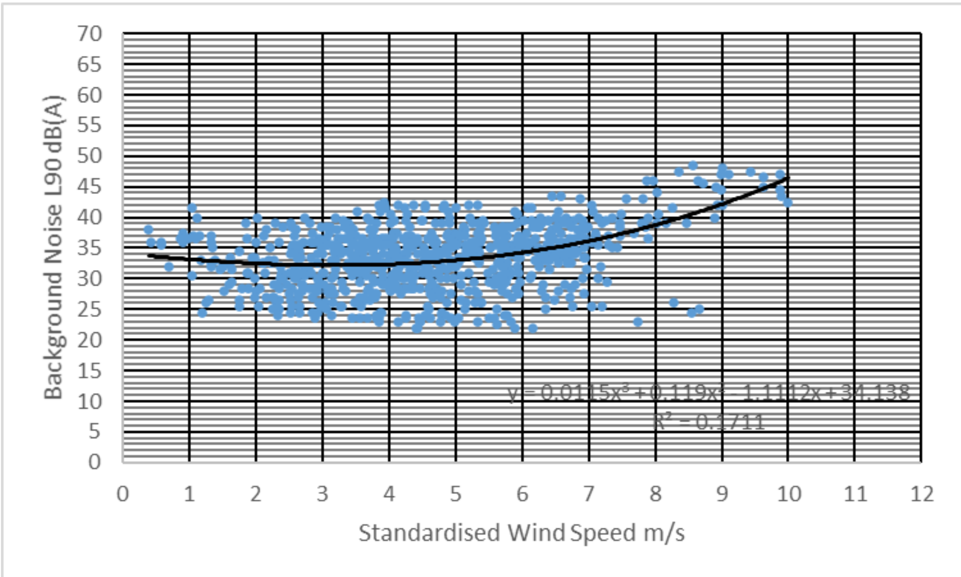
NML 5 Amenity Hours Prevailing Background Noise Level



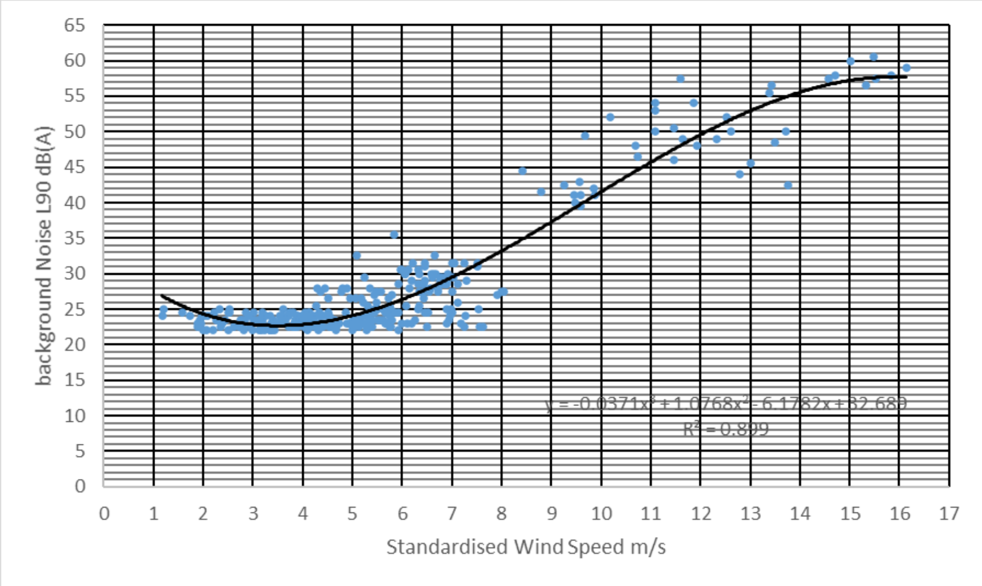
NML 5 Night- Time Prevailing Background Noise Level



NML 6 Amenity Hours Prevailing Background Noise Levels



NML 6 Night-Time Prevailing Background Noise Levels



Tables 11-3 and 11-4 presents the derived $L_{A90\ 10\ min}$ noise levels for the monitoring locations for both the amenity hours and night-time periods. These levels have been derived using regression analysis carried out on the data sets and presented on the graphs above.

Table 11-3 Prevailing Background Noise Levels - Amenity Hours

Location Reference		Wind Speed Standardised to 10m						
Monitoring Location	Representative Of	4	5	6	7	8	9	10
		Prevailing Background L90 dB(A)						
NM 1	15/124/126	31	32	33	35	37	39	41
NM 2	343 / 344 / 363 / 364	32	33	35	37	39	41	44
NM 3	1/ 398	30	31	33	35	36	39	41
NM 4	254 /255 / 270 / 271	33	34	35	38	40	44	49
NM 5	214 / 242 / 243 / 244 / 263 / 264	27	27	30	32	35	38	42
NM 6	285 / 129 / 379 / 305	32	33	34	36	39	42	46

Table 11-4 Prevailing Background Noise Levels - Night Hours

Monitoring Location	Representative Of	Wind Speed Standardised to 10m						
		4	5	6	7	8	9	10
		Prevailing Background L90 dB(A)						
NM 1	15/124/126	21	23	26	29	33	37	41
NM 2	343 / 344 / 363 / 364	22	24	26	29	33	37	42
NM 3	1/ 398	22	24	26	29	32	35	37
NM 4	254 /255 / 270 / 271	25	26	27	30	34	40	45
NM 5	214 / 242 / 243 / 244 / 263 / 264	23	24	26	27	30	33	36
NM 6	285 / 129 / 379 / 305	23	24	26	29	33	37	42

11.3.3 DO-NOTHING SCENARIO

Should the proposed development not proceed it is likely that noise levels will remain unchanged. Vehicle traffic and accordingly noise may increase but, at the same time, more electric vehicles will make up the national car fleet which are much quieter than combustion engine vehicles.

11.4 LIKELY SIGNIFICANT EFFECTS

The following sections describe the potential noise and vibration impact from the proposed Shronowen wind farm and associated infrastructure. The construction, operational and decommissioning phases are assessed.

11.4.1 Construction Phase

The construction phase entails the building of the wind farm infrastructure including, roads, hard standings, turbine bases, drainage system, substation, control buildings, and borrow pits, and also the turbine delivery route works areas. The main noise sources include heavy machinery and support equipment used to construct the various elements. This typically means heavy earth moving machinery, generators and material transport trucks. For the purpose of assessing the likely construction phase impacts, the construction phase has been separated into separate categories as described in the following sections.

The noise levels described in the following sections for the various construction phases are indicative only and are based on theoretical worst case assumptions in order to demonstrate that it will be possible to undertake the works without significant noise impacts.

Figure 11-4 below illustrates the separation distances between the wind farm infrastructure and the nearest dwellings. These distances have been used to calculate the worst-case noise emissions from the different phases of construction.

By their nature the works are temporary and will only potentially impact on a small number of receptors at any one time. In reality construction noise levels averaged over time will be lower than those presented.

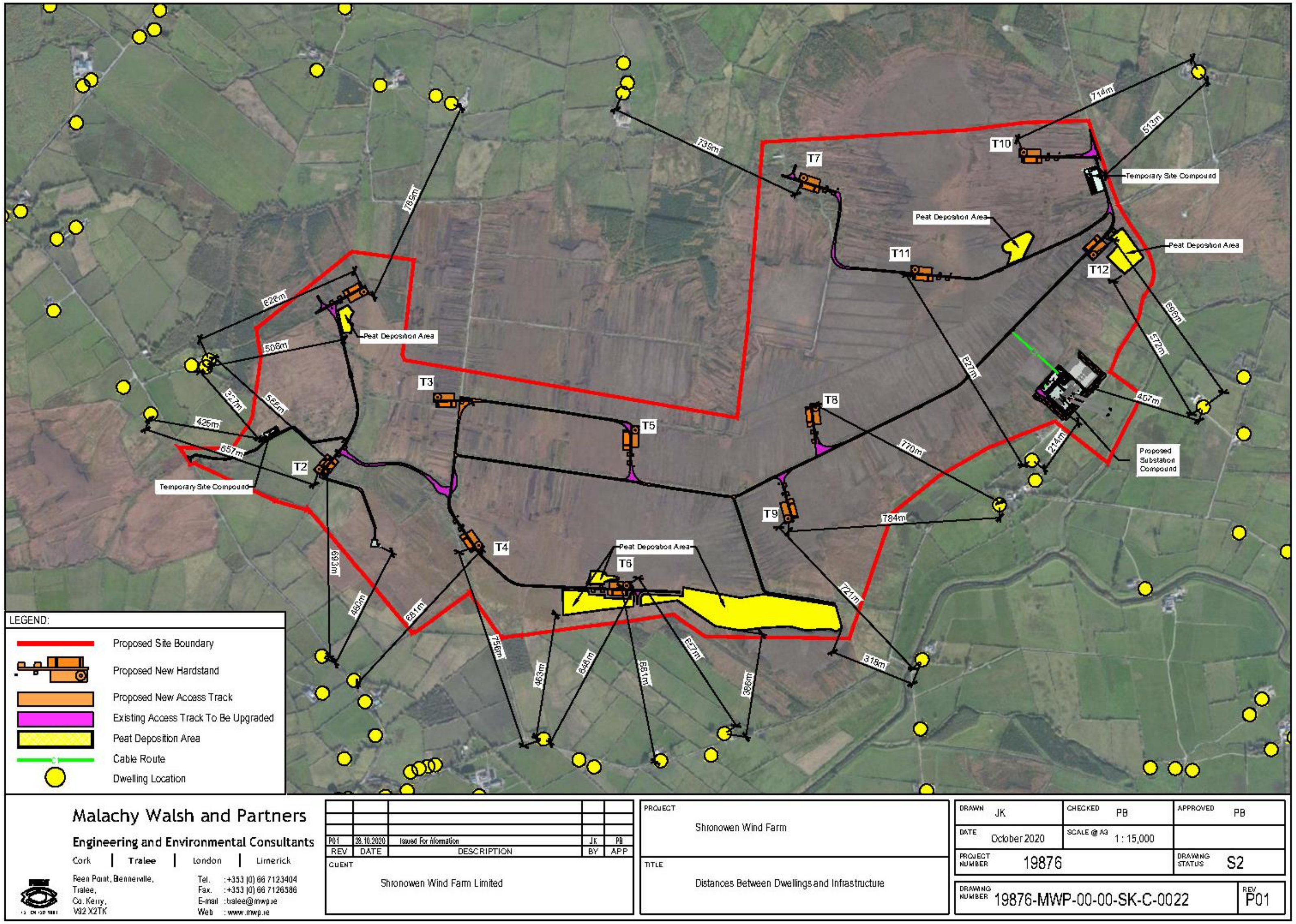


Figure 11-4 Distance between receptors and Infrastructure/ Construction Areas

11.4.1.1 Roads, Cabling and Turbine Erection

In this category, the construction of the wind farm roads will include the noisiest plant and machinery.

The exact equipment to be used is not known at this stage, but the plant and machinery outlined in **Table 11-5** are typical of plant commonly used and can provide an accurate assessment of construction noise emissions.

The associated noise levels have been sourced from *BS 5228 Code of Practice for Noise and Vibration control on construction and open sites*, totalled, and extrapolated to the nearest noise sensitive location. The resultant noise level is then compared against the relevant noise threshold. The result is a theoretical worst case, as it assumes all machinery will be operating simultaneously which will not be the case and accounts for attenuation due to distance only. There will be further noise attenuation due to atmospheric absorption, ground absorption, and landform screening which is not accounted for here. Therefore, the noise levels presented herein are an overestimate.

Using the following equation, noise emissions from the construction site are extrapolated to the nearest noise sensitive receptor.

$$SPL_2 = SPL_1 – 20\log(r2/r1)$$

Where:

- Sound Pressure Level 1 (SPL1) = Known noise level at 10m from construction site
- Sound Pressure Level 2 (SPL2) = Unknown noise level at nearest receptor
- r2 = Distance between noise sensitive receptor and construction site
- r1 = 10 m

Table 11-5 Plant and Machinery and associated noise levels to be used in Wind Farm Roads Construction

Activity	BS 5228, 2014 Sound Pressure Level (@10m (r_1) L_{eq} dB(A)	Predicted Sound Pressure Level @ 300 m (r_2), L_{eq} dB(A).
Dozer (35 tonne) – ground excavation earthworks	86	**61 (SPL_2)**
Wheeled loader – loading lorries	80	
Dump truck (40 tonne) empty	81	
Backhoe mounted hydraulic breaker -Breaking road	73	
Dozer (14 tonne) – spreading chipping/ fill	82	
Road planer (17 tonne) road planing	82	
Road roller (22 tonne) – rolling and compaction	80	
Asphalt paver (and tipper lorry) – Paving	84	
Total	**91 (SPL_1)**	

The above results are calculated for the nearest new road construction within the wind farm. This has been identified as the new access road to the construction compound and T2. The area distance to the nearest noise sensitive location is approximately 300 m.

The theoretical worst case predicted noise level at the nearest noise sensitive location during the roads construction stage is 61 dB(A), which does not exceed the construction noise threshold. The calculations were undertaken at the closest point of the new wind farm road to the nearest receptor. Roads construction is linear, will progress quickly, therefore the calculated noise impact will decrease rapidly as the works progress into the wind farm.

Vibration?

11.4.1.2 Substation Construction

Table 11-6 below is a typical list of plant and machinery involved in substation construction activities. Noise levels from the equipment identified above have been sourced from *BS5228 Noise Database for Noise and Vibration Control on Construction and Open Sites 1& 2: 2014+A1*.

Table 11-6 Typical Construction Plant and Machinery which will be used during the Substation Construction

Plant and Machinery	Sound Pressure Level @10m dB(A)	Predicted Sound Pressure Level @ 200 m L_{eq} dB(A)
Telescopic Handler	71	**60**
Mobile Crane	70	
30-50T Excavator	79	
15-30T Excavator	78	
12T Roller	80	
Dump truck	78	
Tractor & Trailer	79	
15-20T Rubber	68	
3-10T mini digger	69	
Diesel Generator	61	
Total	**86**	

The construction works will be sequenced and all the noise sources in **Table 11-6** above will not be in operation continuously or simultaneously for the duration of the construction. The substation location is approximately 200 m from the nearest noise sensitive receptor. The resultant theoretical worst-case noise emission level at the nearest receptor is 60 dB(A). This is below the construction noise threshold.

Due to the separation distance between the proposed works area and sensitive locations, significant vibrations impacts are not expected. At 200 m distance, vibrations from the construction plant and activities involved will not be perceptible or cause structural or cosmetic damage.

11.4.1.3 Construction Traffic

On a wind farm the most intense period of construction traffic activity takes place during the pouring of the concrete for the turbine bases. This is because all the concrete required for a turbine base must be poured on a single day. The traffic and transport assessment of the project and states that the highest peak hour vehicle traffic volumes would be up to 19 heavy vehicles, both to and from the site (19 deliveries and 19 departures).

For mobile items of plant that pass at intervals it is possible to predict an equivalent continuous sound level using the following expression for predicting L_{Aeq} alongside a haul road used by single engine items of mobile plant:

$L_{Aeq} = L_{wa} – 33 + 10log10Q – 10log10V – 10log10d$,

Where

- L_{wa} is the sound power of the plant in decibels (dB);
- Q is the number of vehicles per hour;
- V is the average vehicle speed, in kilometres per hour (km/h)
- d is the distance of receiving position from the centre of the haul road, in metres (m)

Therefore

$L_{Aeq} = 118^{\text{Note 1}} – 33 + 10Log\ 38 – 10log50 – 10log20 = 71$ dB(A).

Note 1: Source, Maximum drive by sound power level (Table C.2 BS 5228 Part 1).

The averaged L_{Aeq} over the course of an hour from passing HGV's (as calculated above) is predicted to be 71 dBA. While this is above the threshold, the base pours will only occur 12 times (12 turbines) and typically these days will not occur concurrently. In that regard, the noise impact from the HGV concrete deliveries is not considered significant.

11.4.2 Operational Phase

Once operational, the wind turbines and the substation facility will generate noise which will propagate into the receiving environment.

11.4.2.1 Wind Turbines

Noise prediction computer software was used to quantify the impact of the proposed Shronowen wind turbines.

The noise predictions were undertaken using noise prediction software, specifically Bruel & Kjaer's Predictor software (iNoise 2020.1 V1). The software calculations are based on ISO 9613, *Attenuation of sound during propagation outdoors*, *Part 2: General Method of Calculation*. This is the standard recommended by the IOA GPG.

The ISO 9613-2 model can take account of the following factors that influence sound propagation outdoors:

- Geometric divergence;
- Air Absorption;
- Reflecting obstacles;
- Screening;
- Vegetation; and
- Ground reflections

The model uses as its acoustic input data the octave band sound power of the turbine and calculates, on an octave band basis, attenuation due to factors above, as appropriate. The data input into the model was also defined by the IOA GPG and is presented in **Table 11-7**.

Table 11-7 Model Input Data

Item	Description
Turbine Locations	Irish grid 1965
House Locations	Irish grid 1965
Acoustic Emission	Turbine Sound Power Levels
Hub Height	82 m
Landform	10 m contours
Ground Factor	0.5 [Note 1]
Receptor Height	4m
Wind Direction	Downwind
Relative Humidity	70%
Temperature	10°C

Note 1: Ground Factor is a value between 0 and 1, where 0 represents hard/ reflective surfaces and 1, represents soft absorbent surfaces.

Shronowen Turbines

The following sections detail the noise spectra for the wind turbines under consideration for the proposed wind farm.

The maximum operating sound power level of the candidate turbine, namely the Vestas V136 is 106dB(A). The sound power levels (SWL) are presented with reference to the code IEC 61400-11 ed. 2.1, *Wind turbine generator systems, Acoustic noise measurement techniques*, (2006) based on a hub height of 100 m and a roughness length of 0.05 m as described in the IEC code. The SWL presented are valid for the corresponding wind speeds referenced to the height of 10 m above ground level in normal operating mode.

The IOA GPG states that it should be ensured that a margin of uncertainty is included within source wind turbine noise data used in noise predictions. There is uncertainty associated with the measurement of wind turbine noise. This is sometimes included in the warranted noise levels, sometimes it is not. In accordance with the IOA GPG guidelines:

If no data on uncertainty or test reports are available for the turbine then a factor of +2dB should be added.

For the purposes of all predictions presented in this report, to account for various uncertainties in the measurement of turbine source levels, a factor of 2dB has been added to the manufacturer's values.

Table 11-8 Vestas V136 – Total Sound Power Levels

Wind Speed (m/s)	dB LwA	dB LwA (+2dBA)
4	94.5	96.5
5	99.5	101.5
6	103.5	105.5
7	103.9	105.9
8	103.9	105.9

Table 11-9 Vestas V136 – Total Sound Power Levels (including +2dB for uncertainty)

Wind Speed referenced to 10m height w/s	Octave Band (Hz)								
	63	125	250	500	1000	2000	4000	8000	SWL dB(A)
8 m/s	88	92.9	98.3	100.8	100.5	97.3	91.3	82.3	105.9
7 m/s	88	92.9	98.3	100.8	100.5	97.3	91.3	82.3	105.9
6 m/s	87.6	92.5	97.9	100.4	100.1	96.9	90.9	81.9	105.5
5 m/s	84.4	89.3	94.5	96.7	95.8	91.8	84.9	74.8	101.5
4 m/s	79.5	84.4	89.6	91.9	91.2	87.4	80.7	71	96.5

Other Wind Turbines in the Area

The turbine type used for the operational Leanamore wind farm is a Siemens 2.3 MW. The following sound power levels were used herein for the purpose of the cumulative impact assessment.

Table 11-10 Vestas V126 – Total Sound Power Levels

Wind Speed (m/s)	dB LwA	dB LwA (+2dBA)
4	95.1	97.1
5	99.8	101.8
6	104.6	106.6
7	106.4	108.4
>8	106.4	108.4

Table 11-11 Leanamore Wind Turbines - Sound Power Levels Used for Modelling – Octave Bands (including +2dB for uncertainty)

Wind Speed referenced to 10m height w/s	Octave Band (Hz)								
	63	125	250	500	1000	2000	4000	8000	SWL dB
4 m/s	73.1	84.3	88.4	92	92.2	88.8	81.4	77.1	97.1
5 m/s	77.8	89	93.1	96.7	96.9	93.5	86.1	81.8	101.8
6 m/s	82.6	93.8	97.9	101.5	101.7	98.3	90.9	86.6	106.6
7 m/s	84.5	95.4	99.1	103.1	103.1	99.4	92.2	88.2	108.4
>8 m/s	84.5	95.4	99.1	103.1	103.1	99.4	92.2	88.2	108.4

The turbine type used for the operational Tulahennell wind farm and permitted adjacent Ballylongford wind farm is a GE2.x. The following sound power levels were used herein for the purpose of the cumulative impact assessment.

Table 11-12 Vestas V126 – Total Sound Power Levels

Wind Speed (m/s)	dB LwA	dB LwA (+2dBA)
4	92.7	94.7
5	96.7	98.7
6	101.73	103.73
7	105	107
>8	104.98	106.98

Table 11-13 Tulahennell and Ballylongford Wind Turbines - Sound Power Levels Used for Modelling – Octave Bands (including +2dB for uncertainty)

Wind Speed referenced to 10m height w/s	Octave Band (Hz)								
	63	125	250	500	1000	2000	4000	8000	SWL dB
4 m/s	80.4	84.5	86.2	86.5	88.6	89.3	81.7	60.8	94.7
5 m/s	83.9	88.5	90.6	90.5	92	93.2	86.9	65.9	98.7
6 m/s	88.6	93.3	95.7	96.3	97.1	97.8	92	72.8	103.73
7 m/s	92.2	96.6	98.3	99.7	100.9	100.9	95	75.9	107
>8 m/s	92.2	96.7	98	99.4	101	101.1	94.8	75.3	106.98

11.4.2.2 Noise Assessment Results DoEHLG 2006

The results of the assessment shown in tabular form in **Table 11-16** show that the proposed Shronowen wind farm can meet the noise limit criteria as set out in the 2006 DoEHLG Wind Energy Guidelines both as a standalone development and cumulatively with the existing operational and permitted developments in the area at the nearest noise sensitive receptors.

At all locations and at all wind speeds the predicted noise emissions do not exceed the derived limit criteria for both the quiet daytime and night-time periods. The noise limit curves at the selected representative noise monitoring locations are illustrated in **Appendix 11-3**.

The wind turbine noise emission levels included in **Tables 10-16** are based on the $L_{A90,\ 10\ minute}$ noise indicator in accordance with the recommendations in the IOA GPG, which were obtained by subtracting 2dB(A) from the calculated $L_{Aeq\ T}$ noise levels based on the turbine sound power level data used.

Figure 11-5 illustrates the theoretical maximum noise emissions from the wind farm stand alone and cumulative scenarios. Noise levels at receptors may be lower because of local landform or screening and wind direction effects.

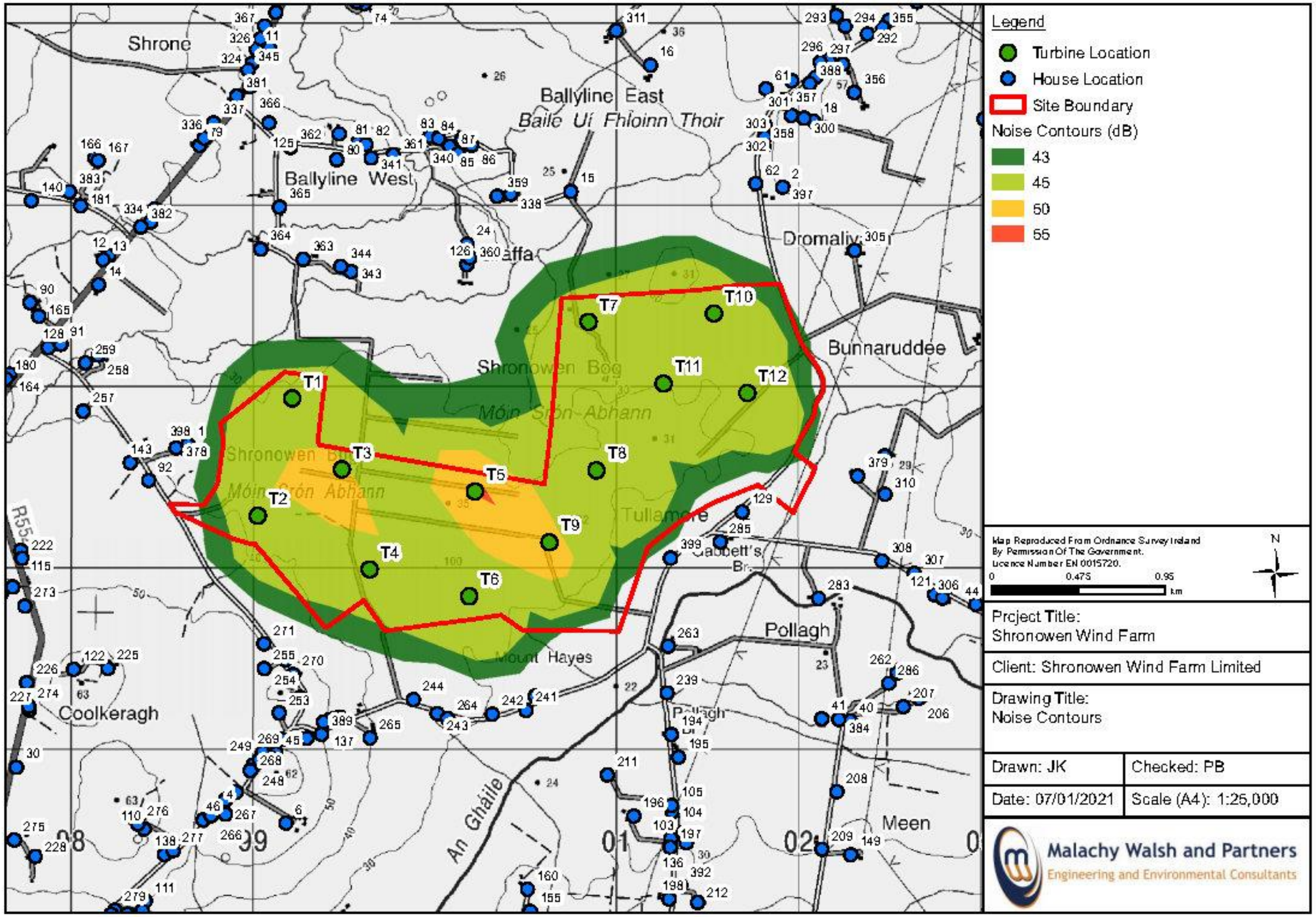


Figure 11-5 Max Noise Emissions Shronowen Wind Farm Alone

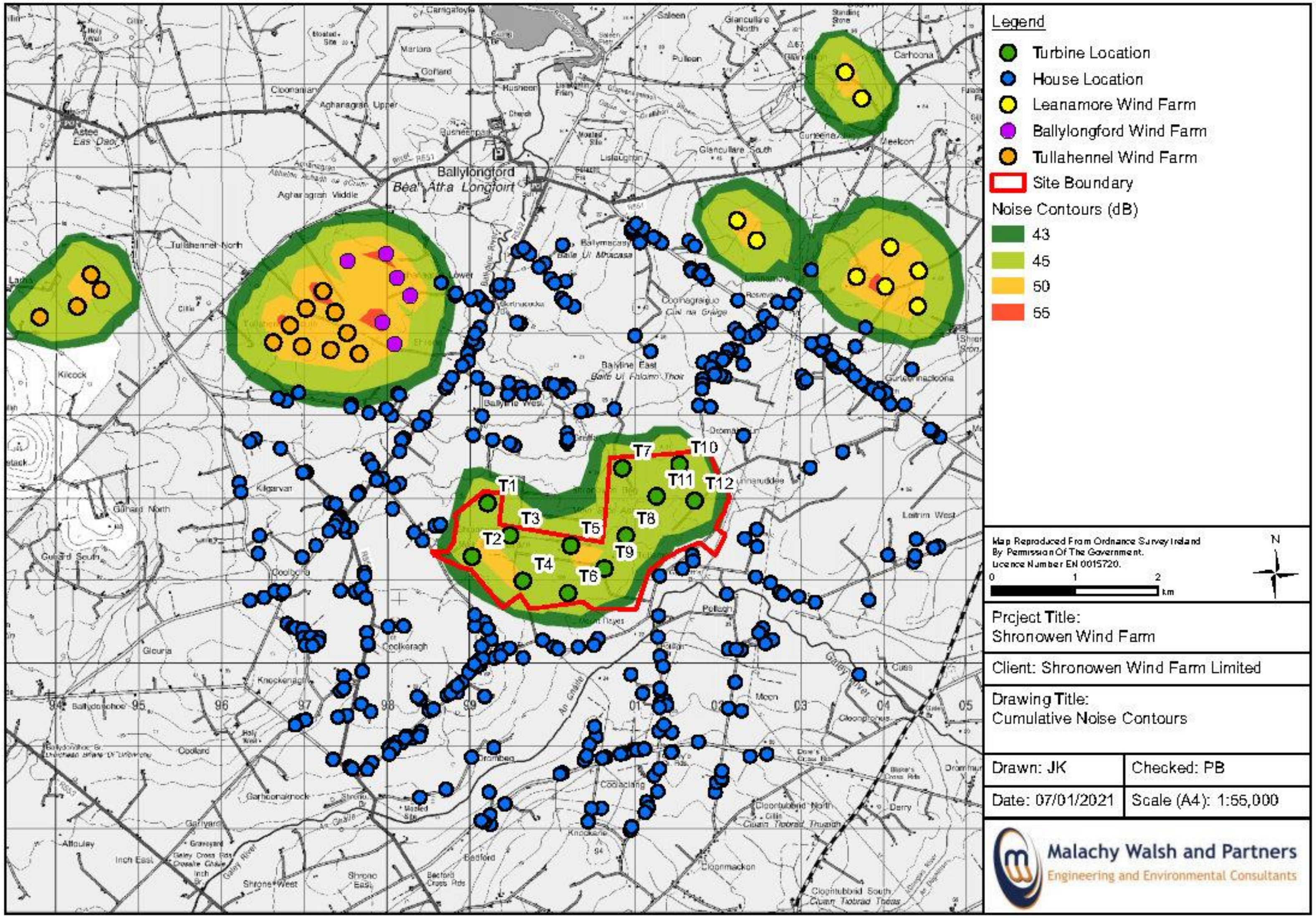


Figure 11-6 Max Noise Emissions All Wind Farms

Table 111-14 Comparison of Predicted Noise Levels (Stand Alone and Cumulative) against Noise Limit Criteria.

Noise Monitoring Location	House Reference Number	Noise Level Descriptor	Total Noise Level dB L_{A90} at Standardised Wind Speed at 10 m AGL						
			4	**5**	**6**	**7**	**8**	**9**	**10**
NML 1	126	Prevailing Background Noise Daytime	31	32	33	35	37	39	41
		Derived Day Limit	**45**	**45**	**45**	**45**	**45**	**45**	**45**
		Prevailing Background Noise Night	21	23	26	29	33	37	41
		Derived Night Limit	**43**	**43**	**43**	**43**	**43**	**43**	**43**
		L_{A90} Predicted Noise Levels (Shronowen Alone)	**30**	**35**	**39**	**39**	**39**	**39**	**39**
		L_{A90} Predicted Noise Levels (Cumulative)	**31**	**36**	**39**	**40**	**40**	**40**	**40**
		Compliance	**√**	**√**	**√**	**√**	**√**	**√**	**√**
NML 2	363	Prevailing Background Noise Daytime	32	33	35	37	39	41	44
		Derived Day Limit	45	45	45	45	45	45	45
		Prevailing Background Noise Night	22	24	26	29	33	37	42
		Derived Night Limit	43	43	43	43	43	43	43
		L_{A90} Predicted Noise Levels (Shronowen Alone)	**29**	**34**	**38**	**38**	**38**	**38**	**38**
		L_{A90} Predicted Noise Levels (Cumulative)	**30**	**35**	**39**	**40**	**40**	**40**	**40**
		Compliance	**√**	**√**	**√**	**√**	**√**	**√**	**√**
NML 3	1	Prevailing Background Noise Daytime	30	31	33	35	36	39	41
		Derived Day Limit	45	45	45	45	45	45	45
		Prevailing Background Noise Night	22	24	26	29	32	35	37
		Derived Night Limit	43	43	43	43	43	43	43
		L_{A90} Predicted Noise Levels (Shronowen Alone)	**31**	**37**	**41**	**42**	**42**	**42**	**42**
		L_{A90} Predicted Noise Levels (Cumulative)	**31**	**38**	**41**	**42**	**42**	**42**	**42**
		Compliance	**√**	**√**	**√**	**√**	**√**	**√**	**√**

Noise Monitoring Location	House Reference Number	Noise Level Descriptor	Total Noise Level dB L_{A90} at Standardised Wind Speed at 10 m AGL						
			4	**5**	**6**	**7**	**8**	**9**	**10**
NML 4	254	Prevailing Background Noise Daytime	33	34	35	38	40	44	49
		Derived Day Limit	45	45	45	45	45	45	45
		Prevailing Background Noise Night	25	26	27	30	34	40	45
		Derived Night Limit	43	43	43	43	43	43	43
		L_{A90} Predicted Noise Levels (Shronowen Alone)	**31**	**36**	**40**	**40**	**40**	**40**	**40**
		L_{A90} Predicted Noise Levels (Cumulative)	**31**	**38**	**40**	**40**	**40**	**40**	**40**
		Compliance	**√**	**√**	**√**	**√**	**√**	**√**	**√**
NML 5	244	Prevailing Background Noise Daytime	27	27	30	32	35	38	42
		Derived Day Limit	40	40	45	45	45	45	45
		Prevailing Background Noise Night	23	24	26	27	30	33	36
		Derived Night Limit	43	43	43	43	43	43	43
		L_{A90} Predicted Noise Levels (Shronowen Alone)	**31**	**36**	**40**	**40**	**40**	**40**	**40**
		L_{A90} Predicted Noise Levels (Cumulative)	**32**	**36**	**40**	**41**	**41**	**41**	**41**
		Compliance	**√**	**√**	**√**	**√**	**√**	**√**	**√**
NML 6	129	Prevailing Background Noise Daytime	32	33	34	36	39	42	46
		Derived Day Limit	45	45	45	45	45	45	45
		Prevailing Background Noise Night	23	24	26	29	33	37	42
		Derived Night Limit	43	43	43	43	43	43	43
		L_{A90} Predicted Noise Levels (Shronowen Alone)	**32**	**37**	**41**	**41**	**41**	**41**	**41**
		L_{A90} Predicted Noise Levels (Cumulative)	**32**	**37**	**41**	**41**	**41**	**41**	**41**
		Compliance	**√**	**√**	**√**	**√**	**√**	**√**	**√**

Noise predictions were carried out for all receptors within the 3 km study area, that is within 3 km of a Shronowen wind turbine. This included receptors that were within the zone of influence of Tulahennell, Ballylongford and Leanamore wind farms.

The results showed that the absolute lower limit value of L_{90} 43dB(A) was achieved cumulatively at each location within the 3 km study area for all wind speeds, bar Locations 78, 123, 168, and 320.

However, the noise prediction analysis shows that the proposed Shronowen development does not contribute cumulatively to the noise levels at these locations. The noise levels from Shronowen turbines are 10 dB below the noise levels from other wind farms at these locations. Due to the logarithmic addition of decibels if one noise source is 10dB below another, there is no increase in noise levels. The noise levels at these locations are shown in **Table 11-15**.

Table 11-15 Cumulative assessment where 43dB(A) lower limit value is exceeded

House Reference Number	Noise Level Descriptor	Total Noise Level dB L_{A90} at Standardised Wind Speed at 10 m AGL						
		4	**5**	**6**	**7**	**8**	**9**	**10**
78	Cumulative Permitted Lower Limit Value Day & Night	43	43	43	43	43	43	43
	L_{A90} Predicted Noise Levels (All others except	33	37	42	45	45	45	45
	L_{A90} Predicted Noise Levels (All others including	33	37	42	45	45	45	45
	L_{A90} Predicted Noise Levels (Shronowen Alone)	19	24	27	27	27	27	27
	Shronowen Contribution (10 dB below)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
123	Cumulative Permitted Lower Limit Value Day & Night	43	43	43	43	43	43	43
	L_{A90} Predicted Noise Levels (All others except	33	37	42	44	44	44	44
	L_{A90} Predicted Noise Levels (All others including	33	37	42	44	44	44	44
	L_{A90} Predicted Noise Levels (Shronowen Alone)	18	22	26	26	26	26	20
	Shronowen Contribution (10 dB below)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
168	Cumulative Permitted Lower Limit Value Day & Night	43	43	43	43	43	43	43
	L_{A90} Predicted Noise Levels (All others except	32	36	41	44	44	44	44
	L_{A90} Predicted Noise Levels (All others including	32	36	41	44	44	44	44
	L_{A90} Predicted Noise Levels (Shronowen Alone)	18	23	26	27	27	27	27
	Shronowen Contribution (10 dB below)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
320	Cumulative Permitted Lower Limit Value Day & Night	34	38	43	44	44	44	44
	L_{A90} Predicted Noise Levels (All others except	33	38	43	44	44	44	44
	L_{A90} Predicted Noise Levels (All others including	34	38	43	44	44	44	44
	L_{A90} Predicted Noise Levels (Shronowen Alone)	18	23	26	27	27	27	27
	Shronowen Contribution (10 dB below)	**0**	**0**	**0**	**0**	**0**	**0**	**0**

It should be noted the predicted Shronowen noise levels are 10dB(A) below the 43dB(A) lower limit thresholds at these locations. This means the Shronowen wind turbines cannot cause the lower limit threshold to be exceeded at these locations.

11.4.2.3 Special Audible Characteristics

There are three categories of special audible characteristics that may arise from wind turbines:

1. Tonal Noise

2. Amplitude Modulation

3. Low Frequency Noise

These are discussed in the following sections.

Tonal Noise

A tone can be described as an identifiable characteristic from a particular sound. It can be commonly described as a whine, hum or hiss. Tonal wind turbine noise can generally be attributed to gearbox related noise. Improvements in turbine design have greatly reduced potential tonal noise.

Such characteristics incur an additional acoustic penalty to the wind turbine noise emission. Typically, wind turbines are broadband in nature and there are no clearly audible tones when operating normally, therefore no penalty has been included.

A warranty will be sought from the turbine manufacturer guaranteeing no tonal content at the nearest noise sensitive receptors.

Amplitude Modulation

The variation in noise level associated with turbine operation, at the rate at which turbine blades pass any fixed point of their rotation (the blade passing frequency), is often referred to as blade swish and amplitude or aerodynamic modulation (AM). It is often referred to as a 'whooping' or 'thumping' noise which may cause annoyance at a considerable distance from the wind energy development.

The Institute of Acoustics (IoA) Working Group defined wind turbine amplitude modulation as follows:

"Wind turbine amplitude modulation is defined as periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), the frequency of the fluctuations being related to the blade passing frequency of the turbine rotor(s)."

This effect is identified within the UK document ETSU-R-97, The Assessment and Rating of Noise from Wind Farms (1996), upon which the Department of the Environment, Heritage, and Local Government, Wind Energy Planning Guidelines, 2006, noise limits are based. ETSU-R-97 states that '*… modulation of blade noise may result in variation of the overall A-Weighted noise level by as much as 3 dB(A) (peak to trough) when measured close to a wind turbine... '* and that at distances further from the turbine where there are '*… more than two hard, reflective surfaces, then the increase in modulation depth may be as much as 6 dB(A) (peak to trough)*'. It concludes that '*the noise levels (i.e. limits) recommended in this report consider the character of noise described ... as blade swish*'.

Modern wind turbines can generate normal AM but this usually disappears at 3 to 4 rotor lengths (with the exception of cross wind conditions). Where the modulation characteristics change, AM can give rise to annoyance. Recent research into AM was conducted by Renewable UK, published as 'Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect' (December 2013). This research focused on the less understood 'Other AM' where reported incidents are relatively limited and infrequent but is a recognised phenomenon. However, the occurrence and intensity of OAM is specific to a location and its likelihood of occurrence cannot be reliably predicted.

Section 6 of the 'Summary of Research into Amplitude Modulation of Aerodynamic Noise from Wind Turbines- Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect' states that "*At present there is no way of predicting OAM at any particular location before turbines begin operation due to the general features of a site or the known attributes of a particular turbine*".

Should AM arise it will be investigated thoroughly and, if a complaint is justified, the required mitigation measures will be undertaken.

Infrasound and Low Frequency Noise

Low frequency noise is noise that is dominated by frequencies less than 200 Hz. It is audible to the human ear, can travel large distances and is difficult to attenuate.

Infrasound is typically described as sound at frequencies below 20 Hz. This is below the threshold of human hearing.

Further information on Infrasound and its potential impact is provided in the EPA document *Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licenced Sites (NG3)*. The document states:

"There is similarly no significant infrasound from wind turbines. Infrasound is high level sound at frequencies below 20 Hz. This was a prominent feature of passive yaw "downwind" turbines where the blades were positioned downwind of the tower which resulted in a characteristic "thump" as each blade passed through the wake caused by the turbine tower. With modern active yaw turbines (i.e. the blades are upwind of the tower and the turbine is turned to face into the wind by a wind direction sensor on the nacelle activating a yaw motor) this is no longer a significant feature."

The final turbine selected for the site will be a modern active yaw turbine.

The Draft 2019 WEDGs state *"There is no evidence that wind turbines generate perceptible infrasound".* It also states the following with regard to low frequency sound:

"Natural levels of low frequency noise arise in the environment. Regular environmental low frequency noise sources include rivers, waterfalls, waves on the sea, and air turbulence from the wind. Occasional short duration sources include thunder, landslides, avalanches and earthquakes. Low frequency noise from man-made sources includes industrial facilities, transportation, mechanical ventilation systems and some household tools and appliances".

If a complaint arises regarding Low Frequency Sound, it will be investigated in accordance with the most appropriate guidance at the time and corrective action will be taken if the complaint is found to be justified.

11.4.2.4 Substation

The proposed substation is approximately 214 m from the nearest noise sensitive receptor. The substation will typically be in operation 24 hours a day, 7 days a week. The noise emission from a substation required for a wind farm development of this size would be in the order of 93 dB(A) Lw.

The predicted noise level associated with the operation of the substation at the nearest noise sensitive receptor is estimated to be 38 dB(A). It is proposed to construct a 4.5m high grass berm around the substation. This screening would offer at least a further 5dB reduction resulting a noise level of 33dB.

This is below the EPA's environmental night-time noise threshold of 35dB(A) for areas of low background noise as described in the EPA's Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG 4).

11.4.2.5 Vibration

Once operational, there will be no significant sources of vibration from the wind farm development. There will be no significant sources of vibration from the ongoing maintenance through the lifetime of the wind farm.

11.4.3 Decommissioning Phase

Plant and machinery like that used for construction will be used during the decommissioning phase. It is expected the works would be quieter as there will be less heavy earth moving machinery and excavation works. The associated traffic volumes would be much lower also. Therefore, it can be assumed if the construction works achieve threshold limit values so will the decommission works. The same limit values will apply.

11.4.4 Risk of major accidents and disasters

There is no interaction between the proposed noise and vibration characteristics of the wind farm project and any risk of major accidents and disasters.

10.4.5 Cumulative effects

The proposed wind farm project has been assessed cumulatively with other relevant permitted and operational projects in the area and the effects have been found to be acceptable.

11.5 MITIGATION

11.5.1 Construction Phase

The construction activities are relatively minor, temporary and of short duration and the impact will not be significant. Therefore, no noise mitigation measures during construction are required. BS5228: Part 1:2009, outlines general measures for the reducing of construction noise levels at source. This best practice document will be referenced and referred to within the overall Construction and Environmental Management Plan (CEMP) for the development.

Piling may be required at the at the turbine foundations. However, given the separation distances to the nearest dwellings, significant impacts are very unlikely. Therefore, no mitigation measures for vibration are required during construction.

11.5.2 Operational Phase

The results demonstrate that the proposed Shronowen wind turbines noise levels at all identified receptors within the 3 km will not exceed the noise limit criteria either permitted or proposed. Therefore, no noise mitigation measures are required.

There are no significant vibrations from operational wind farms. Therefore, no mitigation measures for vibration are required during the operational phase.

11.5.3 Decommissioning Phase

Best practice in the form of BS5228 –1&2:2009 + A1 2014, *Code of Practice for the Control of Noise and Vibration on Construction and Open Sites* will be adopted during the decommissioning phase in order to minimise the noise and vibration generated by construction activities.

11.6 RESIDUAL IMPACTS

11.6.1 Construction and Decommissioning Phase

Potential Impact	Significance of Unmitigated Impact	Mitigation	Residual Impact
Noise Nuisance at nearest noise sensitive receptors	The significance of impact is assessed against the noise limits in the BS5228 Construction Noise Guidelines. As these thresholds are not predicted to be exceeded, then no significant impact is concluded.	Additional mitigation above adhering to best practice referred to herein (BS 5228) is not necessary.	Once the construction and decommissioning phases are over, there will be no residual impact.

11.6.2 Operational Phase

Potential Impact	Significance of Unmitigated Impact	Mitigation	Residual Impact
Noise Nuisance at nearest noise sensitive receptors	The significance of impact is assessed against the relevant noise limit criteria. As these thresholds are predicted not to be exceeded then no significant impact is concluded.	No mitigation is required in order to comply with the noise limit criteria.	Once operational, the noise levels from the turbines will not exceed planning limit criteria for the protection of residential amenity.

11.7 CONCLUSION

This chapter has assessed the potential impact of operational noise from the proposed Shronowen wind farm on the residents of nearby receptors.

Six residential locations neighbouring the proposed development were selected as assessment locations, being representative of the closest properties. Background noise monitoring was undertaken at these locations.

Predictions of wind turbine noise have been made, based upon sound power level data for a representative preferred candidate wind turbine model for the proposed development. Predicted wind turbine noise emissions meet the noise limits established for the assessment for both day and night-time periods.

The operation of the substation compound has also been assessed and can achieve the adopted noise limit criteria at the nearest noise sensitive receptors.

The construction and decommissioning phases of each element of the proposed project has also been assessed and found to comply with construction noise thresholds.

REFERENCES

Attenuation of sound during propagation outdoors –Part 2: General method of calculation, ISO 9613-2-1996- Acoustics.

Code of Practice for Noise and Vibration Control on Construction and Open Sites + A1 2014 British Standard 5228 Parts 1 & 2.

Environmental Management in the Extractive Industry (Non-Scheduled Minerals), Environmental Protection Agency, 2006.

Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise, Institute of Acoustics, 2013.

Guidelines for Environmental Noise Impact Assessment, Institute of Environmental Management and Assessment (IEMA), 2014.

Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4), Environmental Protection Agency, (EPA, 2016)